3060

A comparison of two automated and probabilistic tract segmentation methods

Jonathan D Clayden[1], Susana Munoz Maniega[2], Mark E Bastin[3], and Chris A Clark[1]
[1]*Institute of Child Health, University College London, London, United Kingdom,* [2]*Division of Clinical Neurosciences, University of Edinburgh, Edinburgh, United Kingdom,* [3]*Centre for Clinical Brain Sciences, University of Edinburgh, Edinburgh, United Kingdom*

Intended Audience: Researchers using diffusion MRI to study white matter tracts

Purpose: Manual segmentation of white matter tracts from diffusion MRI (dMRI) data using regions of interest is time consuming and potentially error-prone, due to the complex three-dimensional shapes of most fasciculi. Two tools which are freely available to automate this process are TRACULA, available as part of FreeSurfer [1], and probabilistic neighbourhood tractography (PNT), available through the TractoR package [2]. Both make use of structured prior information to guide their segmentations. In this work we compare the two approaches on a data set of volunteers.

Methods: Diffusion MRI data were acquired from eight healthy volunteers (four male; mean age 26.5 yr, standard deviation 2.5 yr) on a Siemens Avanto 1.5 T clinical scanner. 60 diffusion-weighted gradient directions were applied, with a b-value of 1000 s mm^{-2}, along with three $b = 0$ volumes. Reconstructed voxel size was 2.5 mm in all dimensions. Two T_1-weighted 3D-FLASH volumes with 1 mm isotropic resolution were also acquired, since these are required by FreeSurfer. TRACULA (from FreeSurfer v5.1.0) and PNT (from TractoR v2.2.1) were run using standard pipelines, without any manual intervention. Both methods use very similar preprocessing, and both currently use FSL-BEDPOSTX [3] to model the diffusion data. The tract pruning technique available as a standard part of the PNT pipeline was applied [4]. Reference tracts for PNT were derived from a cohort of 80 normal subjects (39 male) with ages between 25 and 64 yr, while the standard training data set provided with FreeSurfer was used for TRACULA. Run time was on the order of hours for both methods, but was substantially higher for TRACULA due to the requirement to run FreeSurfer's structural segmentation algorithms before beginning dMRI data processing.

Tract segmentations for the forceps minor, forceps major and left-sided cingulum (cingulate gyrus), inferior longitudinal fasciculus (ILF) and uncinate fasciculus were obtained from each method. The images were thresholded at 1% of their maximum value to avoid including negligible voxels, and then the number of voxels within the segmentation, as well as all of the fractional anisotropy (FA) values within these voxels, were obtained. Variation in voxel count and FA was investigated, using a random effects model to separate intersubject and intrasubject variance in the latter case.

Results: Fig. 1 shows group maps of the five tracts studied for each of the two segmentation techniques. These were obtained by transforming the tract from each subject into MNI standard space and overlaying them. It is obvious from this figure that the results from the two techniques are broadly similar, although the TRACULA segmentations tend to be slightly broader.

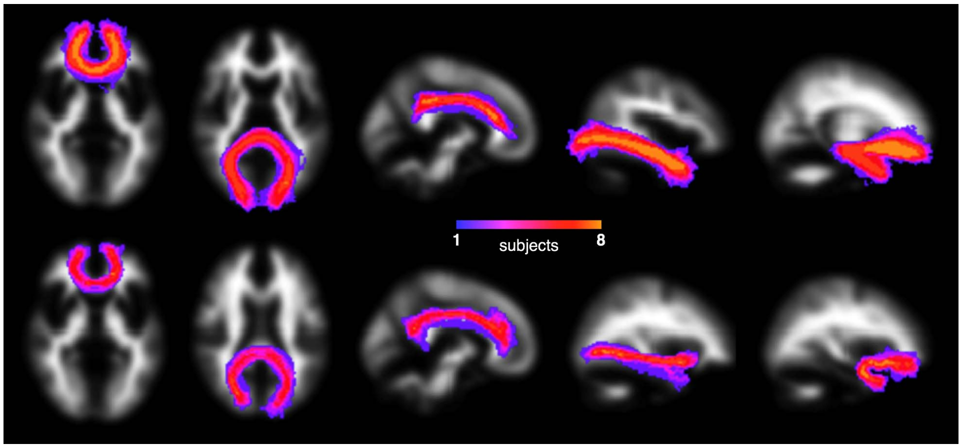

Fig. 1: *Group maps showing overlaid segmentations of (from left to right) forceps minor, forceps major, left cingulum (cingulate gyrus), left ILF and left uncinate fasciculus. TRACULA results are shown in the top row, and PNT results in the bottom row.*

Table 1 shows the mean voxel count of the segmentations, along with its coefficient of variation (CV) across subjects. It is immediately clear that the segmentation extent is both larger and more variable for TRACULA, compared with PNT. Also shown are the grand mean FA (across subjects), and the estimated intersubject and intrasubject CVs. Note that it is unsurprising to see higher intrasubject (within-tract) CVs than intersubject CVs in this case, since tracts pass into grey matter and near cerebrospinal fluid, and so partial volume effects will influence some segmented voxels. FA is generally higher on average for PNT, and intrasubject CV is generally lower, but intersubject CV does not consistently trend one way or the other when comparing the two methods.

Method	**Tract**	**Voxel Count Mean**	**Voxel Count CV, %**	**FA Grand Mean**	**FA Intersubject CV, %**	**FA Intrasubject CV, %**
TRACULA	forceps minor	1262	45.1	0.350	4.6	53.0
	forceps major	1180	48.6	0.415	9.8	49.3
	left cingulum	277	44.8	0.388	11.1	38.7
	left ILF	1007	25.5	0.370	7.2	41.6
	left uncinate	928	41.3	0.328	6.0	43.5
PNT	forceps minor	190	15.7	0.394	12.0	40.2
	forceps major	364	25.8	0.469	8.0	38.4
	left cingulum	208	16.0	0.360	4.3	42.7
	left ILF	217	17.1	0.467	4.0	30.3
	left uncinate	278	19.0	0.341	11.1	39.8

Table 1: *Summary statistics for tract coverage and FA after thresholding for each of the two methods under test.*

Discussion & Conclusion: In this work we have compared two probabilistic, automated tract segmentation methods on a cohort of volunteer subjects. While no gold standard is available to compare the results to, we have seen that both methods perform consistently and well. The main difference is that PNT with tract pruning tends to produce segmentations of a slightly narrower and less variable extent, leading to higher mean FA and less variance across segmented voxels. PNT also has the advantages of running more quickly and not requiring T_1-weighted structural images to be available. Further work will be required to establish the methods' relative performance on clinical data sets.

References: **[1]** A. Yendiki et al., *Front Neuroinform* **5**:23 (2011); **[2]** J.D. Clayden et al., *NeuroImage* **45**:377 (2009); **[3]** T.E.J. Behrens et al., *NeuroImage* **34**:144 (2007); **[4]** J.D. Clayden et al., *Lect Notes Comp Sci* **5762**:150 (2009).